



## Training Course...

- Handbook
- Website
- Poster
- Nuclides.net
- Test
- Laboratory Visits
- Certificate
- CD
- **Nuclide Explorer**



### ABOUT THE TRAINING COURSE

The course will be on the use of Nuclides.net, a new software product from ITU, for training purposes in the nuclear industry, health physics and radiation protection, nuclear and radiochemistry.

Nuclides.net is an integrated environment for computations on radionuclides and their radiation. The "integrated environment" is a suite of computer programs ranging from a powerful user-friendly interface, which allows the user to navigate the nuclide chart and explore the properties of nuclides, to various computational modules for decay calculations, dosimetry and shielding calculations, etc.

Course will cover the basic properties of nuclides, isotopes and radiation, and introduces the participants to decay calculations, radiation dosimetry and shielding calculations, etc.

### ABOUT ITU

The Institute for Transuranium Elements is part of the Joint Research Centre (JRC) of the European Commission. The function of the JRC is to serve as a reference centre of science and technology for the European Union. The mission of ITU is to protect the European citizen against risks associated with the handling and storage of highly radioactive elements. ITU's prime objectives are to serve as a centre for basic actinide research, to contribute to an effective safety and safe-guards system for the nuclear fuel cycle, and to study technological and medical applications of transuranium elements.

For more information on ITU, check the latest Activity Reports at the ITU web site: <http://itu.jrc.ec.europa.eu/>  
18/01/2003 - JRC/ITU  
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## Radioactivity, Radionuclides & Radiation

A computer-based  
training course with  
**Nuclides.net**



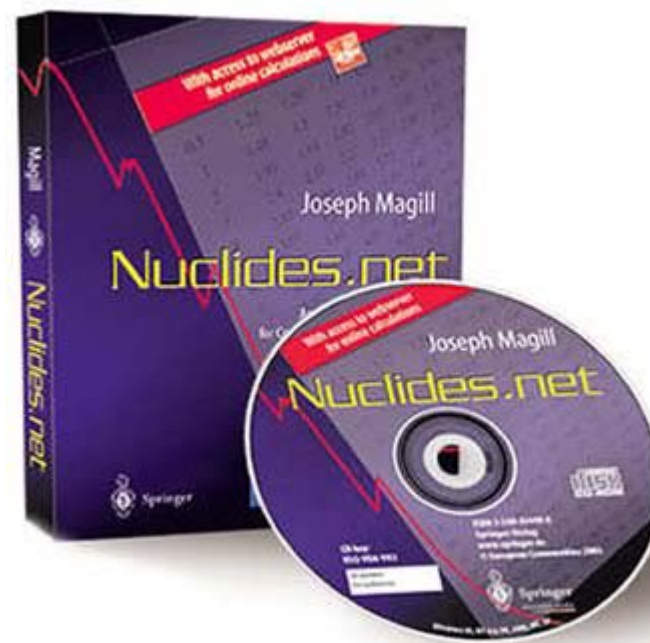
18-19 September 2003  
Karlsruhe • Germany





## Course Handbook

Nuclides.net: An Integrated Environment for Computations on Radionuclides and their Radiation, Springer Verlag 2003





EUROPEAN COMMISSION  
DIRECTORATE-GENERAL  
Joint Research Centre

# Overview of the Training Course...



Joint Research Centre

Nuclides.net  
website:  
[www.nuclides.net](http://www.nuclides.net)



Web-based  
Computations on  
Radionuclides and  
their Radiation



INSTITUTE FOR  
TRANSURANIC  
ELEMENTS



EUROPEAN COMMISSION  
JOINT RESEARCH CENTRE



Developed by scientists  
working on a daily basis  
with radionuclides.

Ideal for education and  
training purposes in the  
nuclear industry, health  
physics and radiation  
protection, and in nuclear  
and radiochemistry.

Suitable for non-experts  
and experts alike for  
reference data on  
radionuclides and  
computations using these  
data.



[Poster: The World of Nuclides](#)

Explore the properties  
of nuclides online!  
(registered users)

Login

Search this site!

Search

powered by Google™

Take a tour!

[Quick Tour](#)  
(html, 3,8 MB)

[Nuclides.net tour](#)  
Macromedia Flash,  
1,3 MB)

[des](#)  
[Chart tour \(Macromedia](#)  
Flash, 620 KB)

Try our online demo...

[Universal Nuclide](#)  
[Chart and Radioactive](#)  
[Decay Applet](#)

[New!](#)  
EC sponsored training course on "Radioactivity, Radionuclides, and Radiation" with Nuclides.net. The course is aimed at EU Candidate Countries (Bulgaria, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, Turkey)  
- If you are interested in taking part in this course, please [read the instructions](#) and send us the [completed application form](#).

-courses planned for summer 2003 at ITU in Karlsruhe, Germany\_

[Introduction](#)

[Features](#)

[Info brochure](#)  
(detailed, Powerpoint, 4 MB)

[System Requirements](#)

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Revised March 23, 2003







## The World of Nuclides

<http://www.nuclides.net/>

EUROPEAN COMMISSION  
JOINT RESEARCH CENTRE

© European Communities, 2002  
Dr. Joseph Magill  
Institute for Transuranium Elements  
Postfach 2340 • 76123 Karlsruhe • Germany



### Chart of the Nuclides

Nuclides with atomic number Z and neutron number N can be arranged in a nuclide chart. Each nuclide is represented by a coloured box indicating the main decay mode. It can be seen that stable isotopes lie within a relatively narrow range indicating that the neutron to proton ratio must have a certain value or range of values to be stable. Radioactive nuclei mostly lie outside this range. The chart also shows that for low atomic numbers, the neutron to proton ratio is unity. At higher atomic numbers, this value increases indicating a higher ratio of neutrons to protons in heavy atoms.

The stability of nuclei is extremely significant for special numbers of protons and neutrons. These "magic" numbers are 2, 8, 20, 28, 50, 82 and 126 and correspond to full shells in the shell model of the nucleus. The element tin with the proton number Z = 50, for example, has 10 stable isotopes, more than all other elements. When the proton and neutron numbers both have magic values, the nucleus is said to be "doubly magic".

### Colour Key

- Stable
- Alpha particle emission
- Beta minus emission
- Beta plus emission or electron capture
- Spontaneous fission
- Proton emission
- Neutron emission

### Halo Nuclides

For most nuclides, the density of nucleons in the nucleus is more or less uniform. However, in certain nuclei, some neutrons are only weakly bound to the inner core nucleons. The nucleus then consists of a normal nucleus surrounded by a halo of extra neutrons with a diameter very much larger than the core nucleus. The halo neutrons are mostly outside of the strong nuclear force between the nucleons. Typically half-lives of these nuclei are around 10ms.

One such example of a halo nuclide is lithium-11. It consists of a lithium-9 core surrounded by a halo of two loosely bound neutrons requiring only 0.3 MeV to remove them. The lithium-11 nucleus is similar in size to that of calcium-48. The neutron halo, however, extends to fill the volume equivalent to  $^{20}\text{Ne}$ . Other examples are helium-6 (He-4 + 2n), helium-8 (He-4 + 4n), beryllium-11 (Be-10 + n), beryllium-14, boron-17 and carbon-16.

### Conan the Bacterium

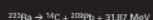
The bacterium *Deinococcus radiodurans* or *D. radiodurans*, which means "strange berry that withstands radiation", was first identified in 1956. It was isolated from a can of beef which had been radiation sterilised. Normally bacteria do not withstand the radiation processing. This was not the case, however, with *D. radiodurans* now affectionately known as Conan the Bacterium.

*D. radiodurans* is extremely resistant to massive doses of ionising radiation. Following a radiation dose in excess of 10,000 Sv (thousands of times higher than the lethal radiation dose in humans), the radiation damaged the bacterium's genetic material by breaking each of the chromosomes into more than one hundred pieces. Due to a unique repair system, which efficiently repairs the damage to its DNA, the bacterium returns to normal within a few hours.

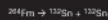
The bacterium is believed to be as old as the Earth and could have been one of the earliest forms of life on the planet. Due to its radiation repair abilities it could even have come from space.

### "Magic" Radioactivity

In 1964, Rose and Jones at Oxford University discovered a new rare type of radioactivity in  $^{223}\text{Rn}$ . They showed that the  $^{223}\text{Rn}$  parent partly decays directly to  $^{219}\text{Po}$  by the emission of a 30 MeV  $^{14}\text{C}$  ion i.e.



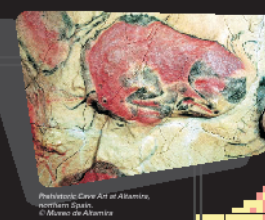
Since then, emission of  $^{14}\text{C}$  from  $^{223}\text{Rn}$ ,  $^{224}\text{Ra}$ ,  $^{226}\text{Ra}$ , as well as  $^{246}\text{Cm}$  from  $^{237}\text{Np}$ ,  $^{241}\text{Pu}$  and  $^{250}\text{Pu}$  have been observed. The discovery of trans cluster emitters may confirm the idea of "magic" radioactivity proposed by Sandulescu in 1989. Magic numbers in the trans-iron region are at N = 50 and 82 and Z = 50. The doubly magic closed shell nuclides  $^{132}\text{Sn}$  and  $^{160}\text{Po}$  lie far from the line of stability. In the region around Ba-Sm cluster emission would lead to nuclides close to the doubly magic  $^{132}\text{Sn}$ . Cold fission as a special case of cluster radioactivity where the fission fragments lie in the Z=50 region. An example is the decay of fermium i.e.



in which the neutron rich fermium splits into two doubly magic tin fragments.

### Prehistoric Cave Art at Altamira

The most famous of the Altamira paintings are on the plafond - a low ceiling in one of the caves to the left from the entrance. The total area of the ceiling is about 100 m<sup>2</sup>. Here the artist skilfully combined pigment painting with the ceiling relief. The majority of more than 20 animal figures are bison though there is also a horse, a boar and a deer. The most common pigments used in these paintings were red  $\text{Fe}_2\text{O}_3$ , black  $\text{MnO}_2$  and charcoal. Rather than dating the sample by traditional techniques of activity measurements (where sample requirements would damage the artwork), accelerator mass spectrometry was used to count individual carbon isotopes thereby reducing the amount of sample required to a minimum. To obtain the carbon needed for dating, a scalpel was used to scratch off approximately 20-40 mg from a dark section of the painting. Radiocarbon dating of the charcoal used to draw the bison shown above found the drawing to be 14000 ± 400 years old.



Prehistoric Cave Art at Altamira, northern Spain. © Museo de Altamira



Courtesy CERN, High Energy Physics Laboratory

### An Astrophysical Clock

Heavy elements such as uranium formed in a supernova more than 6000 million years ago. From the supernova remnants, the solar system was born around 4600 million years ago. Assuming uranium isotopes were produced in equal amounts in the supernova, the ratios of uranium isotopes can be used as an astrophysical clock. Today, the natural abundance of U-235 ratio is 0.71%. The recently discovered 'Isar' has been dated to around 7 million years. In the diagram this is almost indistinguishable from the present time.



© B. A. Auer

### How "constant" is the decay constant?

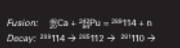
Can the nuclear decay "constant" be influenced under extreme conditions of temperature, pressure, etc? Following the discovery of radioactivity, many attempts to modify decay rates were made by changing temperature, pressure, magnetic fields, and gravitational fields (experiments in mines and on the top of mountains, using centrifuges). In one attempt, Rutherford actually used a bomb to produce temperatures of 2500 °C and pressures of 1000 bar albeit for a short period of time. No effect on the decay constant was detected.

In 1947 Segre suggested that the decay constant of atoms undergoing electron capture (EC) could be modified by using different chemical compounds of the substance. It is also to be expected that the decay constant can be modified by pressure. These chemically induced changes in the decay constant are small but measurable. Recently the spontaneous fission rates of uranium and plutonium have been increased many orders of magnitude using very high power laser radiation at Rutherford Laboratory in the U.K. and at the Friedrich-Schiller Universität in Jena. This laser induced fission arises, however, through photon induced reactions within the nucleus.

### The Superheavy Elements

The idea of the existence of a group of stable elements out with the main nuclear "island" dates back to the 1930s and received considerable attention in the 1960s. The location of a smaller island of stability at Z=114, N=184 was suggested in 1966. The isotope Z=114, N=184 has a doubly magic configuration with both the protons and neutrons being in complete shells.

In the years 1981-94, the GSI group at Darmstadt, Germany, reported the synthesis of elements 107 (Bohrium), 108 (Hassium), 109 (Meitnerium), 110 and 111 (as yet unnamed). In 1999, a Russian team in Dubna, produced for the first time element 114 by bombarding (fusing) nuclei of plutonium-242 with calcium-48. The scientists had to bombard the plutonium with calcium nuclei for a period of six weeks to produce a single nucleus of element 114. The compound nucleus of element 114 had the remarkably "long" half-life of 30 s before undergoing a series of alpha decays to element 108 over a time period of approximately 30 minutes.



### Nuclear waste disposal and natural analogues

One of the challenges facing the nuclear industry is to demonstrate that an underground repository can contain nuclear waste safely for very long periods of time. One way of building confidence in engineered barriers is by studying the processes which operate in natural and archaeological systems and by making appropriate parallels with a repository. These studies are called "natural analogues". Natural analogues provide a way of informing the wider public on the principles on which repositories are built, without using complex mathematical demonstrations of "safety" and "risk". Some notable natural analogues are:

• The Oklo natural fission reactors. The natural fission reactors at Oklo in Gabon, Africa can be considered as analogues for very old radioactive waste repositories.



© CEA

• Dunarobba forest. The Dunarobba forest in Italy, which have been preserved in day, are of relevance in repository concepts since the wood is considered to be analogous to the organic/cellulosic materials which comprise a large part of the waste.



© CRIDEA

• The Needle's Eye. In south-west Scotland, mineral veins of uranium are partly exposed. Pitchblende has undergone dissolution by leaching/dissolution. The location is ideal for investigating radionuclide migration.



Courtesy M.E. Brookfield



# Overview of the Training Course...



### Applications

#### Universal Nuclide Chart

#### Nuclide Explorer

#### Fission Yields

#### Averaged Cross Sections

#### Decay Calculations

#### Dosimetry & Shielding

#### Gamma Spectrum

### Data/Information

#### Data Sheets

#### Fact Sheets

#### Search Engine





Test.....

# Overview of the Training Course...



Radioactivity, Radionuclides & Radiation - Computer-based Training Courses with Nuclides.net  
(18-19<sup>th</sup> Sept, and 23-24<sup>th</sup> Oct. 2003)



Training Course Test

## DataSheets

1. Calculate the energy released (i.e. the decay energy or Q-value) in the spontaneous transformation of Po-210 to Pb-206 by alpha emission.
2. Calculate the average alpha particle energy for the spontaneous transformation of Po-210 to Pb-206.
3. Calculate the maximum kinetic energy of the betas released in the spontaneous transformation of Sr-89 to Y-89. What is the average beta kinetic energy? Note that the average kinetic energy is approximately 1/3 of the max. value.
4. Calculate the energy released in the spontaneous transformation of Na-22 to Ne-22.

## Decay Engine

5. The activity of Sr-90 is 18,000 transformations per minute. What is the mass of Sr-90?
6. What is the time required for the activity of Na-24 to diminish to 1% of its initial value?
7. What mass of Ra-226 will yield the same activity as one gram of Po-210?
8. What initial mass of F-18 is required in order that there are 3 mg remaining after 16 hours?
9. At  $t=0$ , there are 10 Ci of Sr-90 alone. What will be the activity of Y-90 after 5 years?
10. At  $t=0$ , there are 10 Ci of Ra-226 alone. What will be the activity of Rn-222 after 2 days?

## Virtual Nuclides

11. Ra-226 transforms to Rn-222. At  $t=0$ , there is one gram of Ra-226 and 1 mg of Rn-222. What will be the activity in Ci of Rn-222 after 7 days?

## Dosimetry and Shielding

12. What is the gamma dose rate at 1 m due to a 1 Ci un-collimated isotropic source of I-131?
13. Calculate the approximate dose rate at a distance of 2m from a 240 MBq cobalt-60 source.
14. Calculate the activity of a Na-22 source which gives a dose rate of 64  $\mu\text{Sv/h}$  at 1m.
15. The dose rate to a valve is 160  $\mu\text{Sv/h}$ . If this is due to cobalt-60 inside the valve, how much lead shielding must be placed around the valve to reduce the dose rate to 10  $\mu\text{Sv/h}$ ?
16. A cobalt-60 source gives a dose rate of 400  $\mu\text{Sv/h}$  at 1m. At what distance from the source must a barrier be placed if the dose rate at the barrier must not exceed 25  $\mu\text{Sv/h}$ ? What thickness of lead would give the same protection at the original distance?







## Visit to the Labs.....





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## Training Course Certificate....



itu







## The CD.....



Nuclides.net - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites Media History Mail Print Edit Discuss

Address E:\index.html

Radioactivity – Radionuclides – Radiation  
A Multi-Media Training Course with Nuclides.net

Radioactivity – Radionuclides – Radiation  
A Multi-Media Training Course with Nuclides.net  
(18- 19<sup>th</sup> September 2003)

**Agenda:**

**Thursday 18<sup>th</sup>**

09:00	Welcoming address	G. Lander, ITU Director
09:05	Overview of the Nuclides.net program suite	J. Magill
09:35	Electronic Nuclide Charts & Nuclide Explorer	J. Magill
10:05	DataSheets/FactsSheets/Articles/Weblinks	V. Berthou
10:50	Decay Calculations with Nuclides.net	J. Magill
11:25	Dosimetry & Shielding with Nuclides.net	J. Galy
12:00	Universal Nuclide Chart	V. Berthou
14:00	CASE STUDY I: (Partitioning):Thorium Purification	J. Galy
14:30	CASE STUDY II: (Dating): "Age" of Uranium Materials	A. Morgenstern

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nuclides.net

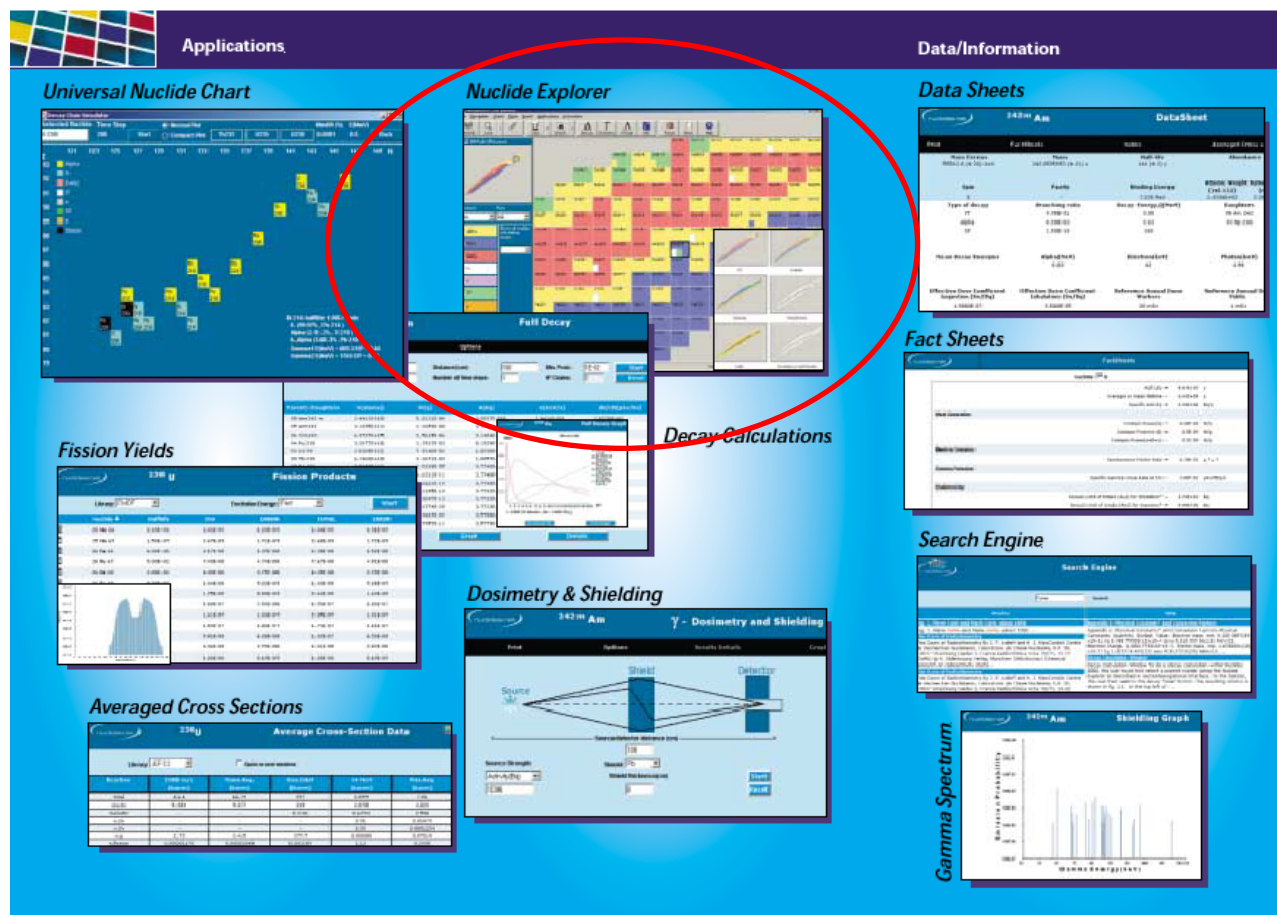
My Computer





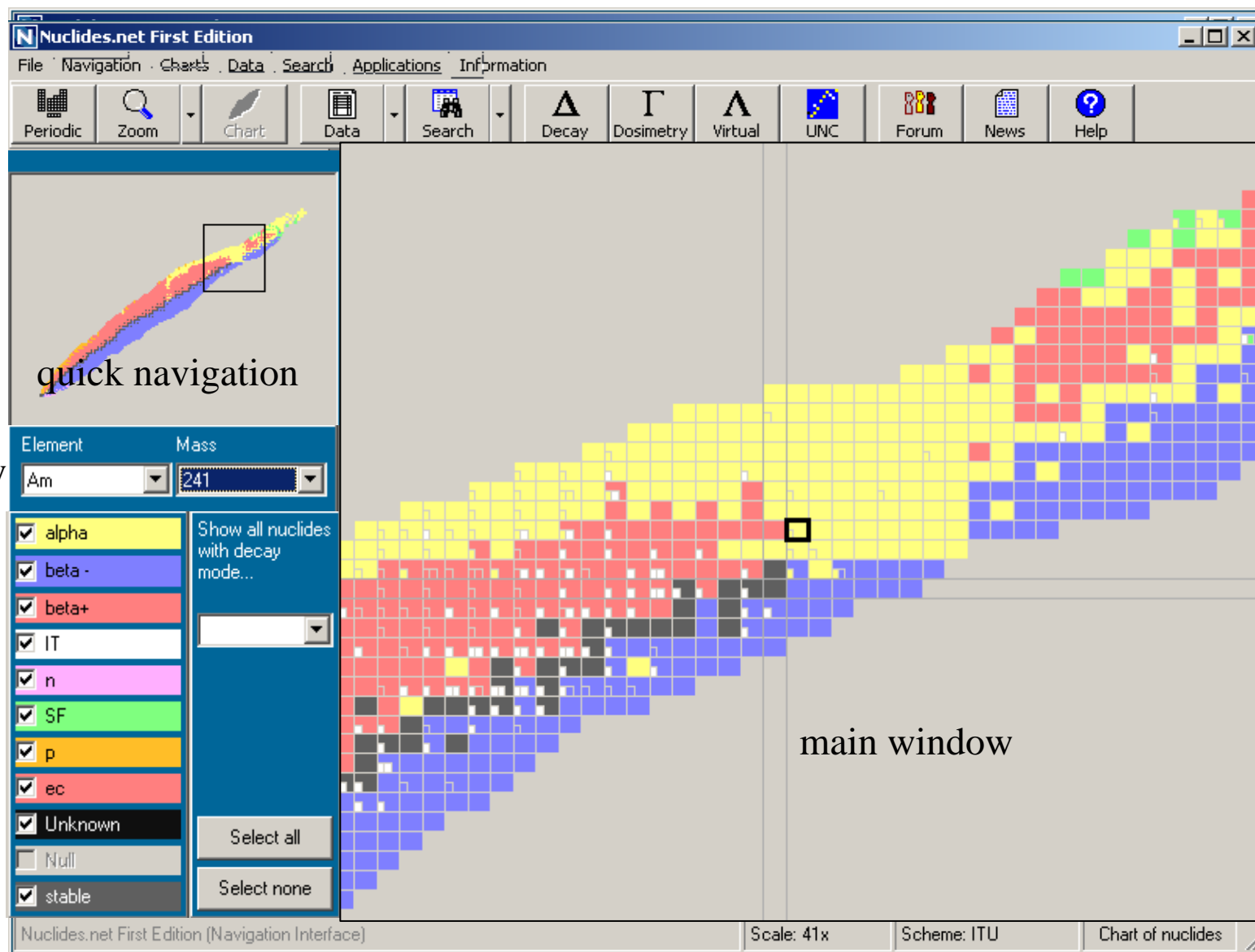
## Nuclide Explorer.....

- User Interface
- Zoom
- Charts
- Colour scheme (main decay modes)
- Colour scheme (all decay modes)
- Property filter
- Build your own chart





# Overview of the Training Course...



direct entry

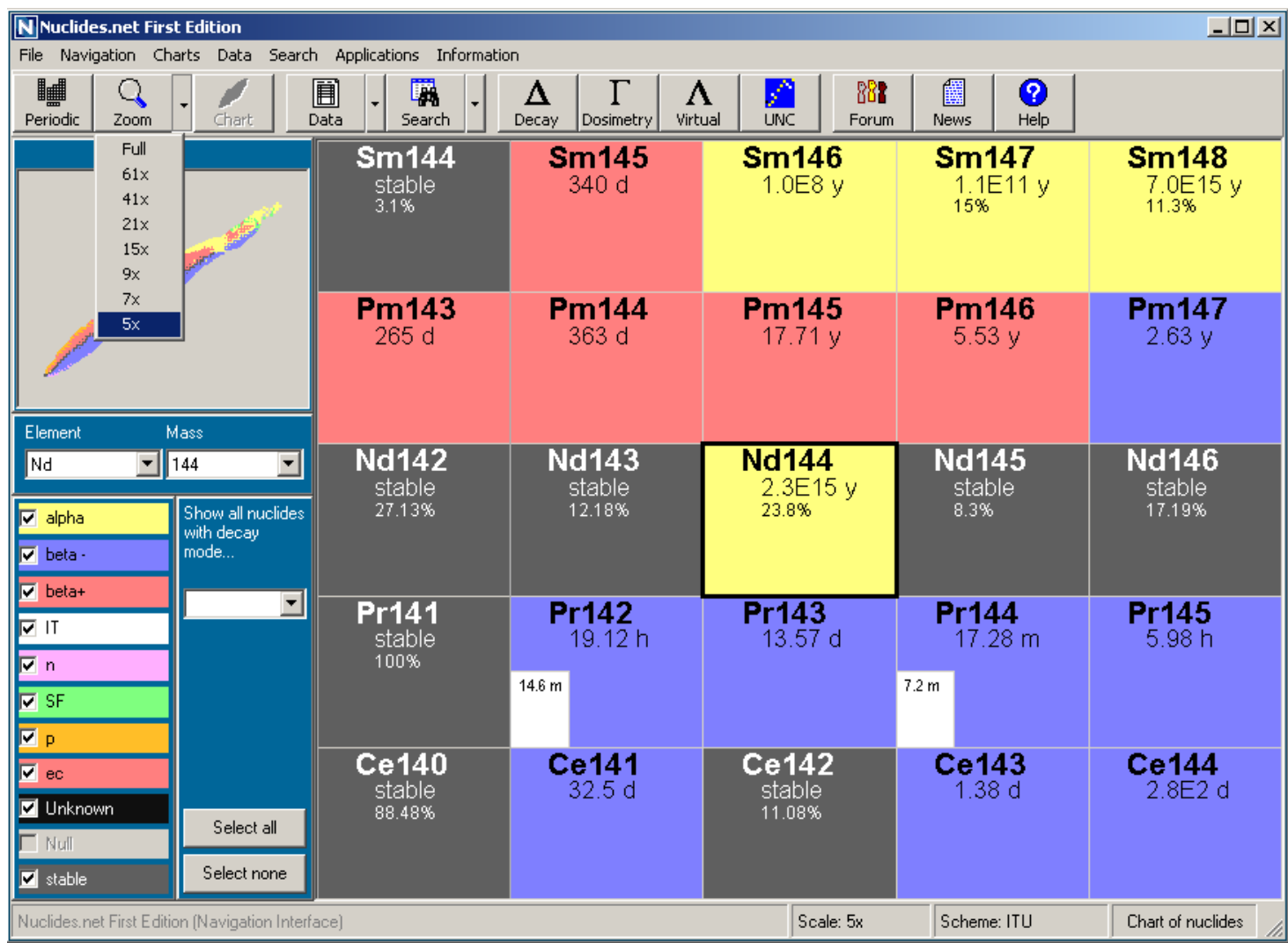
property filter





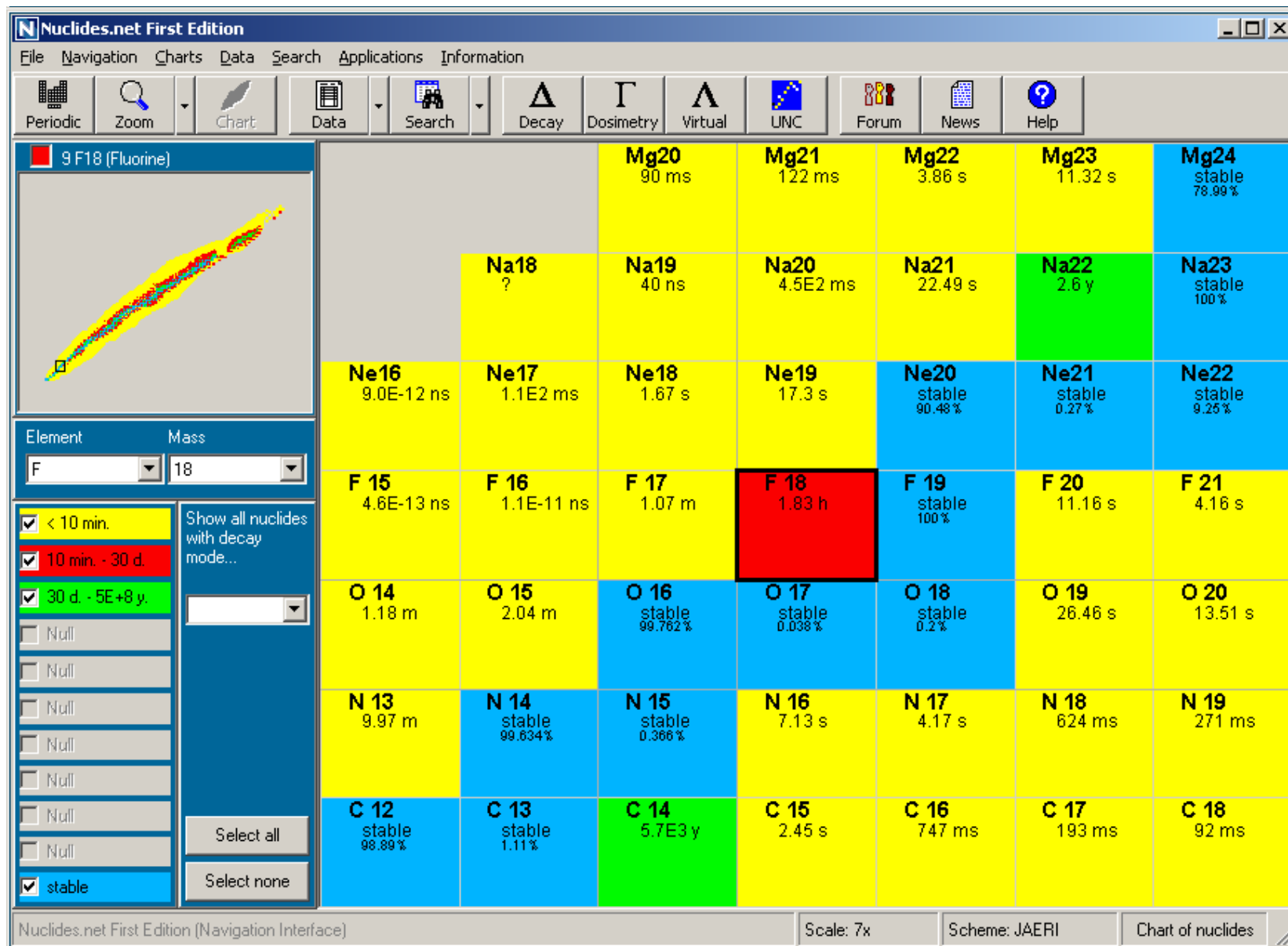


Zoom also with the +- keys in the keypad or  $\uparrow\downarrow$  on the keyboard



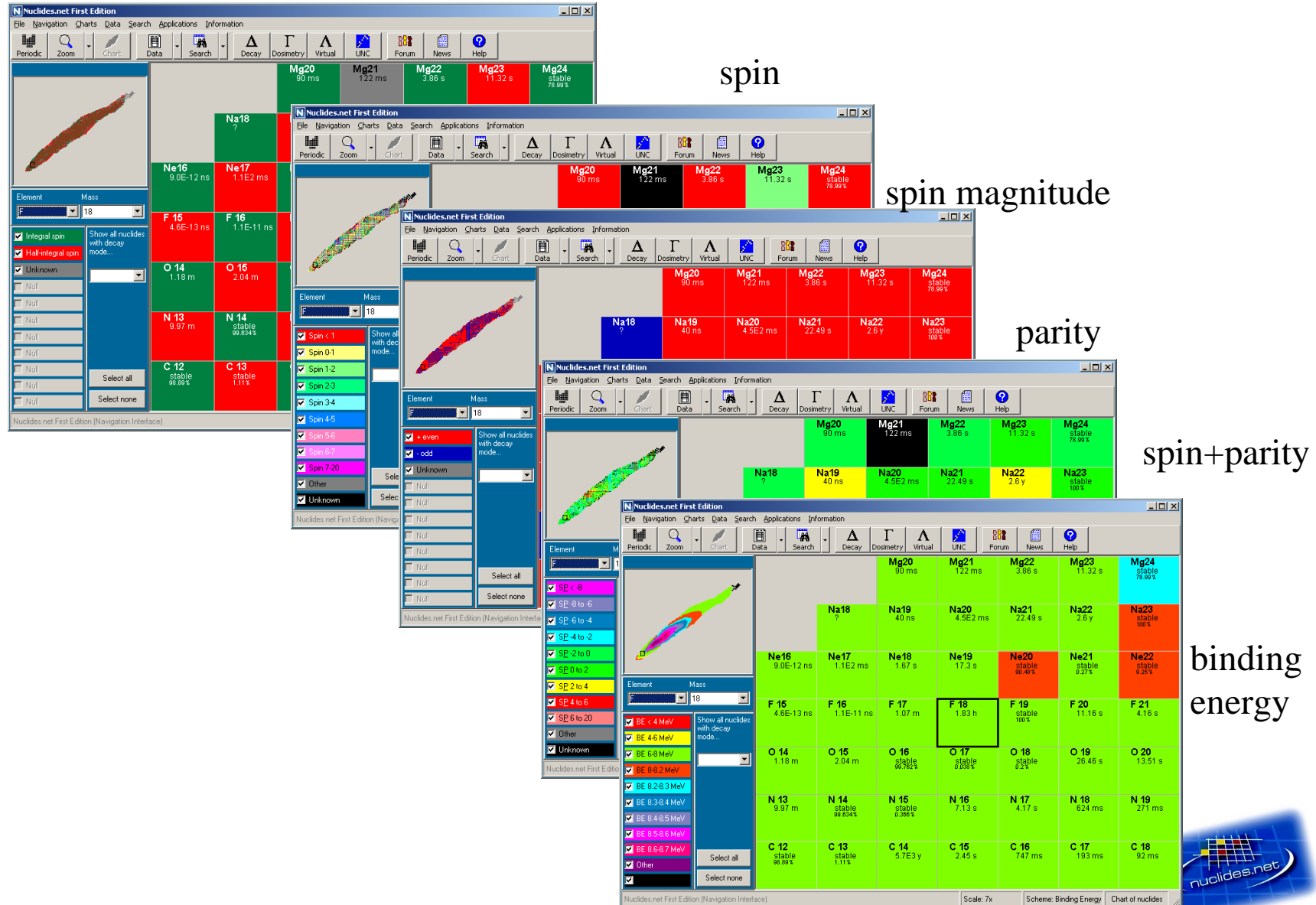


## Charts.....





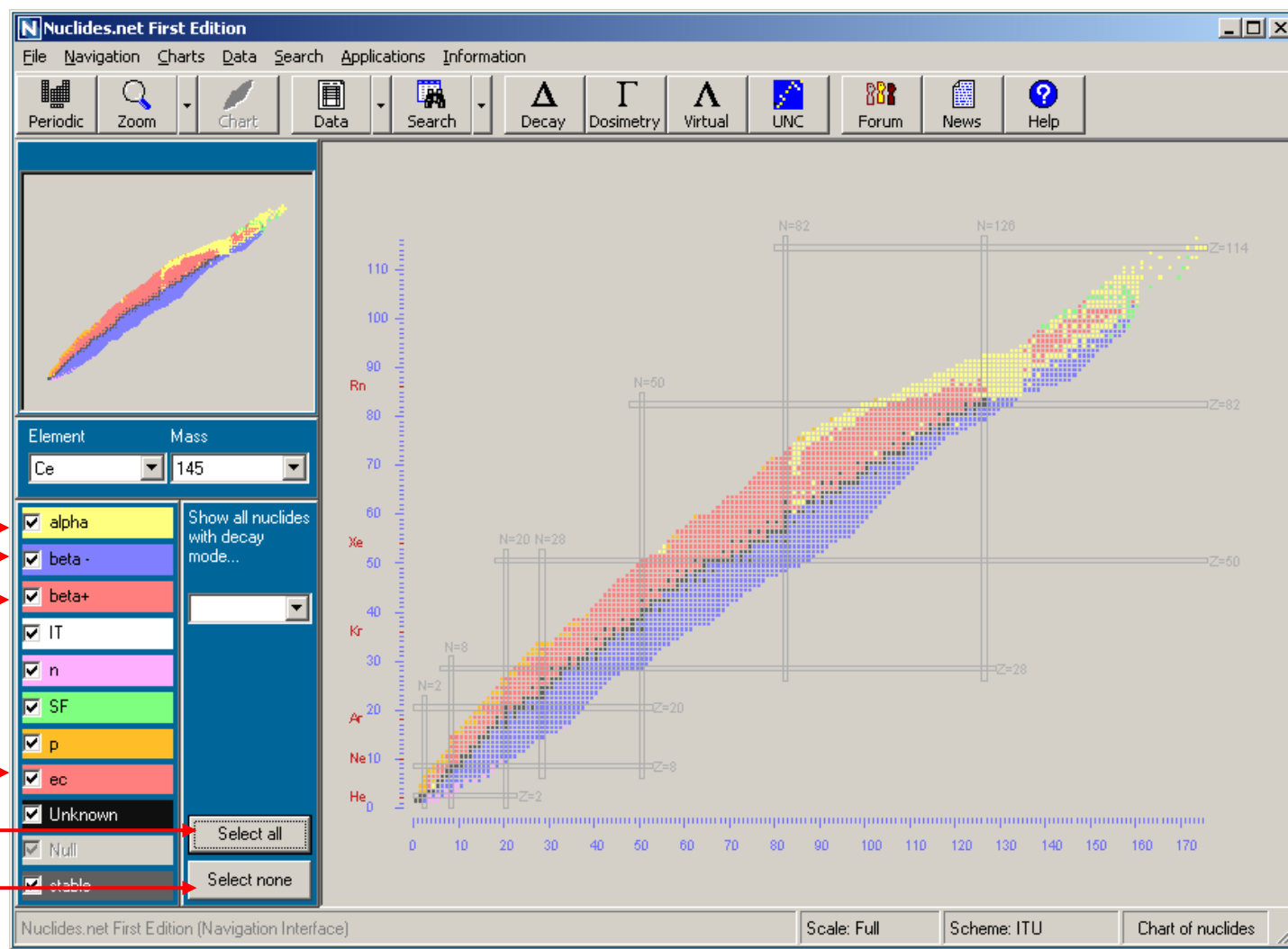
## Charts cont.....





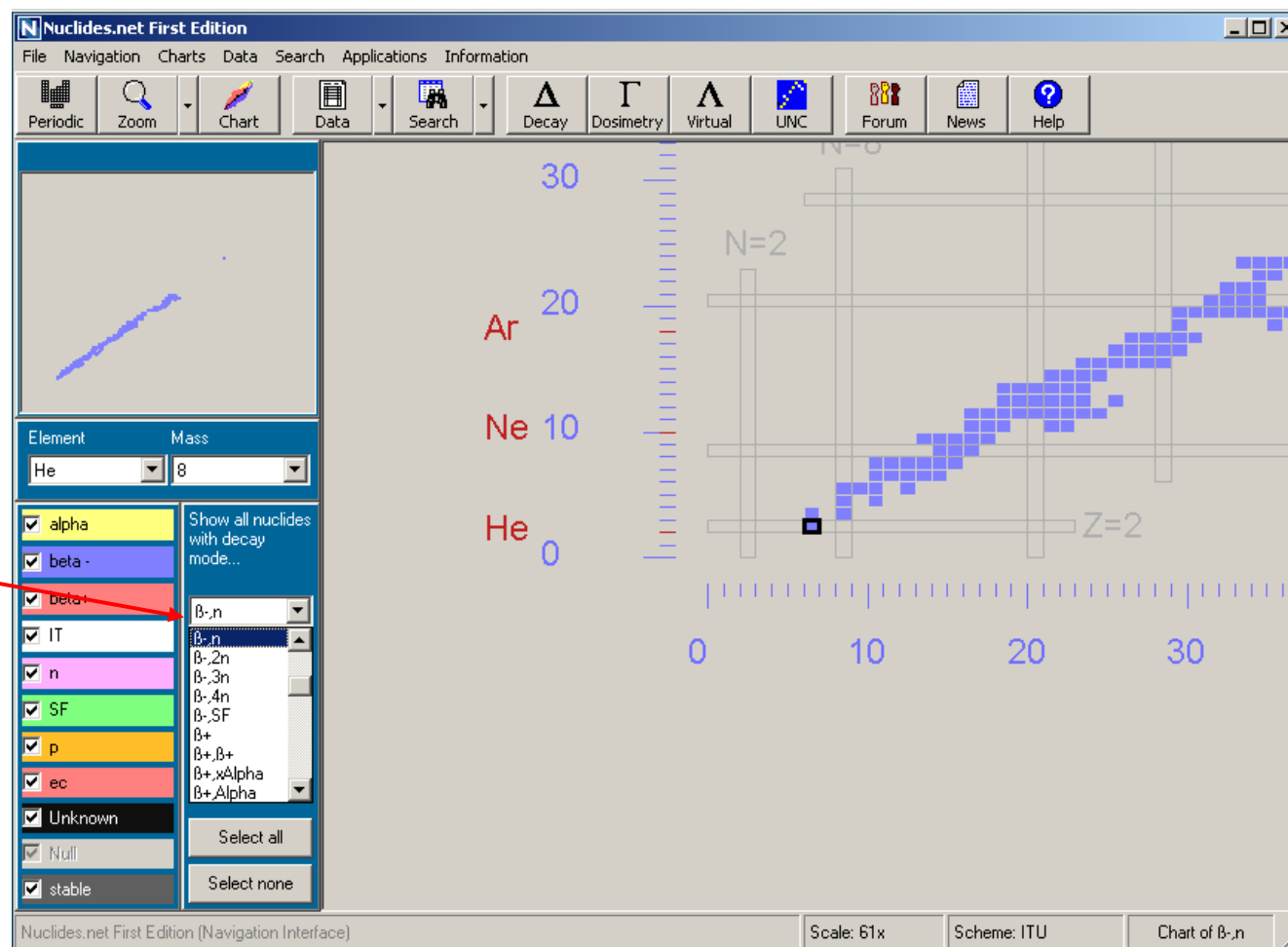


Decay modes: Colours shown refer to the main decay only





Show all  
nuclides  
with  
decay  
mode...

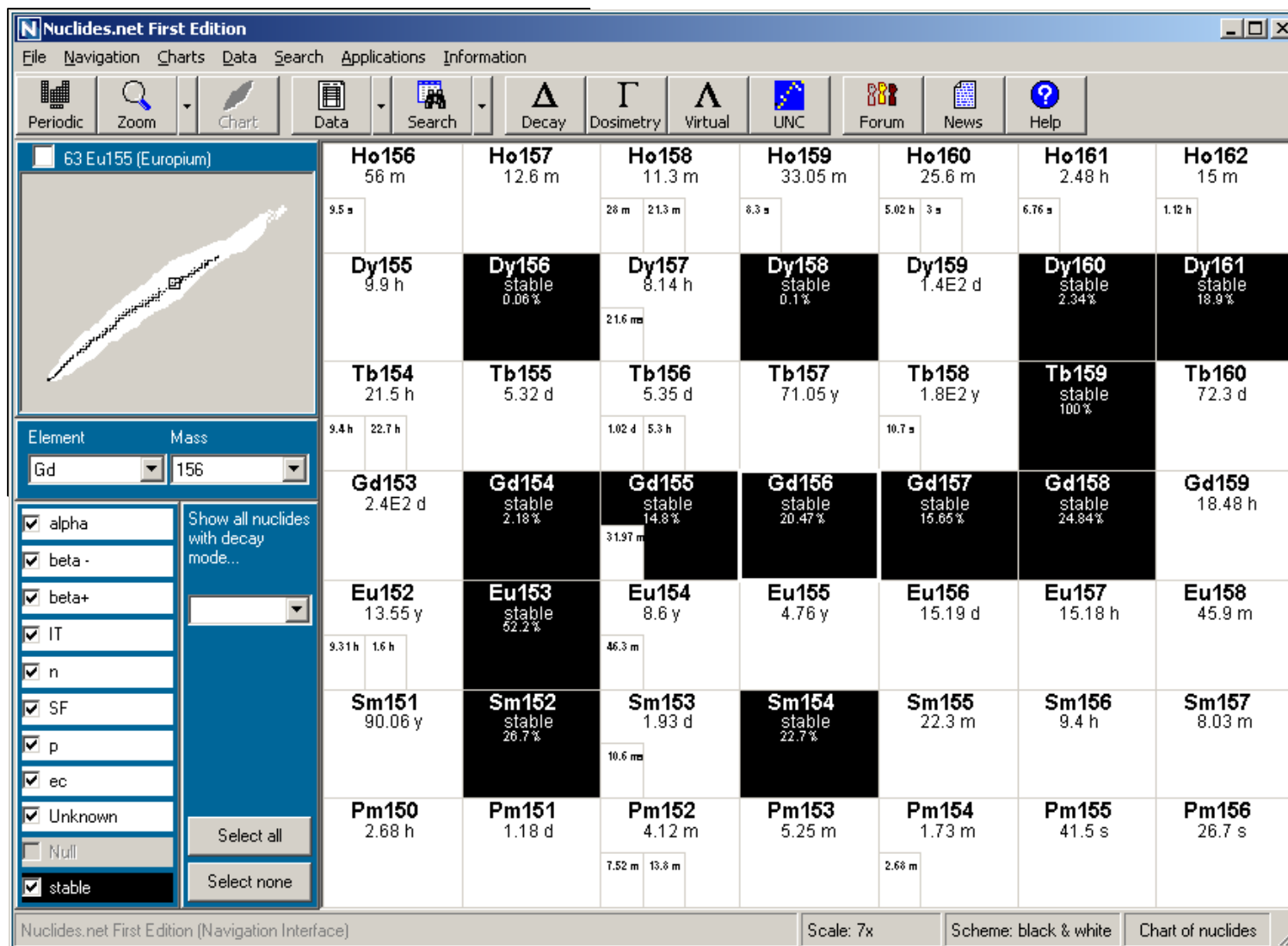




# Overview of the Training Course...



Build your own nuclide charts....





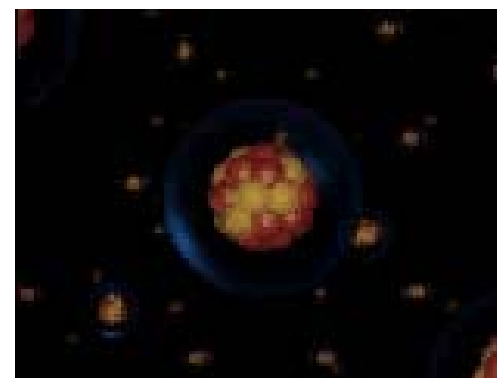
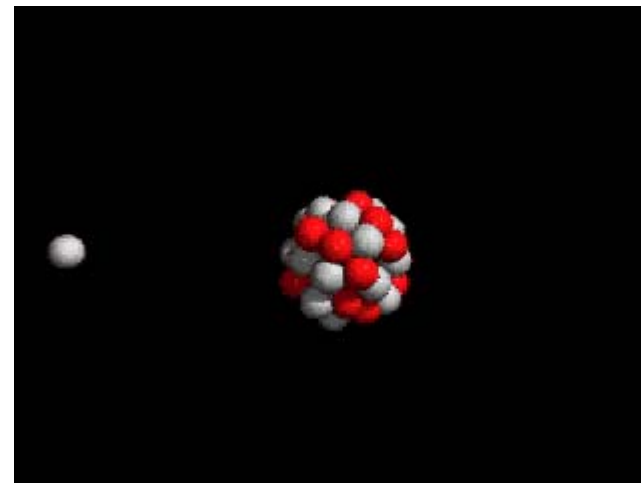


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# Overview of the Training Course...



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## Training Course...

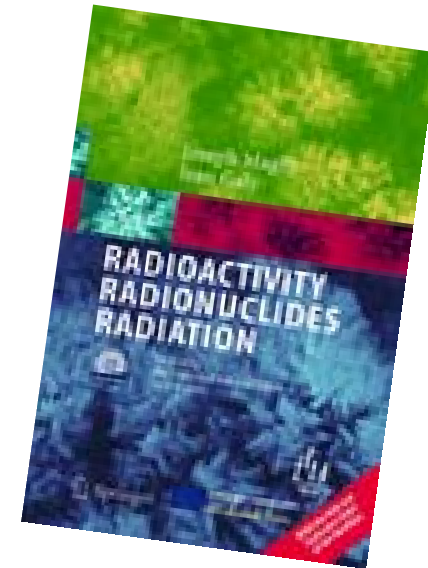
- Handbook
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- Nuclides.net
- Test
- Laboratory Visits
- Certificate
- CD
- **Nuclide Explorer**





## New Book.. Springer Verlag 2004

**RADIOACTIVITY – RADIONUCLIDES – RADIATION** is suitable for a general audience interested in topical environmental and human health radiological issues such as radiation exposure in aircraft, food sterilisation, nuclear medicine, radon gas, radiation dispersion devices ("dirty bombs")... It leads the interested reader through the three Rs of nuclear science, to the forefront of research and developments in the field. The book is also suitable for students and professionals in the related disciplines of nuclear and radiochemistry, health physics, environmental sciences, nuclear and astrophysics. Recent developments in the areas of exotic decay modes (bound beta decay of 'bare' or fully ionized nuclei), laser transmutation, nuclear forensics, radiation hormesis and the LNT hypothesis are covered. Atomic mass data for over 3000 nuclides from the most recent (2003) evaluation are included. The book contains a CD-ROM with the Universal Nuclide Chart – an interactive, platform independent JAVA-program for displaying basic nuclear data, decay processes and neutron reactions together with a fold-out version of the most recent Karlsruhe Chart of the Nuclides.







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For more information on ITU,  
check the latest Activity Reports at the ITU web site:  
<http://itu.jrc.ec.eu.int/>

ISPR Unit - JRC Ispra  
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## Radioactivity, Radionuclides & Radiation

A computer-based  
training course with  
**Nuclides.net**



Karlsruhe • Germany





## PROGRAMME AND TOPICS

- ◆ Background on Radioactivity
- ◆ Nuclide Charts and the Nuclide Explorer
- ◆ Universal Nuclide Chart\*
- ◆ Data sheets
- ◆ Decay calculations
- ◆ Dosimetry and shielding
- ◆ Nuclide mixture
- ◆ Fission products and yields
- ◆ Cross-sections
- ◆ Installation of Nuclides.net
- ◆ Overview of Nuclides.net program suite
- ◆ Case studies
- ◆ Special topics

\* The Universal Nuclide Chart and Radioactive Decay Applet in Nuclides.net has been recommended as a high quality internet resource in the physical sciences by



PSIgate [Physical Sciences Information Gateway]  
is the physical sciences hub of the Resource Discovery Network

## KARLSRUHE



For more information about Karlsruhe, see  
[www.karlsruhe.de](http://www.karlsruhe.de)

## REGISTRATION

The course is suitable for participants who come from the nuclear industry, nuclear research organisations, universities, regulatory authorities or nuclear medicine institutes.

Basic knowledge on the physics and chemistry of radionuclides, radioactivity and radiation is required. The course will be held in English.

The completed application form should be sent to Dr. Jean Galy. Please note that there is a limited number of participants in each course.

## COSTS

Details on the course fees can be obtained from Dr. Jean Galy (see under Contacts).

For the new and future countries of EU, a budget exists to support their participation for accommodation, transport and course fees.

## HOTEL RESERVATION

A block booking for hotels in Karlsruhe will be made.  
A bus will fetch the participants at their hotel to go to ITU.

## WEB LINK

For further information on the Nuclides.net software:  
<http://www.nuclides.net/>

## CONTACTS

### Scientific & Organisational matters

Dr. J. Magill  
European Commission  
Joint Research Centre  
Institute for Transuranium Elements  
Postfach 2340  
D-76125 Karlsruhe  
Germany  
Tél: +49 (0) 7247 951-366  
E-mail: [magill@itu.fzk.de](mailto:magill@itu.fzk.de)

Dr. J. Galy  
Tél: +49 (0) 7247 951-220  
E-mail: [jean.galy@itu.fzk.de](mailto:jean.galy@itu.fzk.de)



## Nuclides.net Mission Statement....

Our job is to continuously extend and improve the software modules and optimize the Nuclides.net software environment so that scientists can concentrate on the results

